THURSDAY, AUGUST 22, 1907.

APPLIED OPTICS.

A System of Applied Optics, being a Complete System of Formulae of the Second Order, and the Foundation of a Complete System of the Third Order, with examples of their Application. By H. Dennis Taylor. Pp. xvi + 334, with 24 plates. (London : Macmillan and Co., Ltd., 1906.) Price 30s. net.

THAT branch of geometrical optics which deals with the properties of lenses and lens systems has unfortunately been shamefully neglected in England during recent years. This neglect has extended from the theory to its practical applications, and the design and construction of lenses has, to a great extent, been relegated to other countries, notably Germany; although in the time of Dollond, M. Anthéaume was obliged to send to England in order to obtain lenses to carry into practice the theory of achromatism devised by M. Clairaut. Before the publication of the book which forms the subject of this review, there was no work, in English, by the guidance of which an ordinary photographic lens could be worked out in all particulars; and the fact that there has been practically no demand for translations of the numerous books on applied optics which have been published in Germany, shows how completely the subject has been neglected. If we seek for a reason to explain this state of affairs, it is not far to seek. The books on geometrical optics which have appeared in England during recent years have, for the most part, been written by mathematicians who could boast little or no acquaintance with the practical design of lenses; and as the formulæ which can be obtained for the correction and elimination of errors in lenses do not possess that " elegance " which is dear to the heart of the pure mathematician, practically no progress has been made since the time of Airy and Coddington : almost the only modern work which exhibits originality of treatment is a small volume [1] by Mr. Blakesley, published in 1903.

In these circumstances we cannot feel too grateful to Mr. Dennis Taylor for the volume before us. In this, everything which could aid the student in mastering the subject in the easiest and most pleasant way has been done, and done well. The numerous diagrams (drawn to scale, or as nearly to scale as is practicable), which are included in the twenty-four plates, must alone have entailed many hours of tedious labour. The principles underlying each problem that is attacked and solved are clearly and fully explained, while the steps in the analysis which have been omitted can easily be supplied by a reader with very moderate mathematical acquirements. But the chief interest of the book lies in the fact that it is the outcome of a successful attempt to design lenses for practical purposes. Finding that the formulæ arrived at by Coddington, for the curvature of the image formed by a lens, were not quite satisfactory, an

attempt was made to solve the problem by some method not dependent on the calculus; and after several disappointments, Mr. Taylor was successful.

In this investigation the formulæ relating to " coma " or " side flare " were arrived at; it is significant that there is scarcely a book in English which even mentions this defect of lenses—a defect which is often of greater importance than those due to spherical aberration or astigmatism. As a practical outcome of the investigation, the Cooke lens was designed; and, finally, Mr. Taylor has embodied his investigations in the book before us.

It is, perhaps, a pity that Mr. Taylor has not adopted the usual convention as regards the signs of the quantities u, v, and r. In the end, one convention (when mastered) is as good as another; therefore, it would appear that the most suitable one is that which is most generally adopted. The convention adopted by Mr. Taylor makes u positive or negative (for a particular position of the object), according as the lens is collective or dispersive, while the signs of v, and the radii of curvature are determined in a similar manner. There appears to be no advantage in this procedure that is not shared equally with the one generally in use; and the reader accustomed to the latter is likely to experience some unnecessary difficulty in following Mr. Taylor's reasoning. This is, however, a detail of no vital importance.

The first chapter of Mr. Taylor's book is devoted to a brief recapitulation of the ordinary formulæ, of the first order of approximation, applied to mirrors and lenses. In the second chapter the " theorem of elements " is explained : a thick lens is shown to be equivalent to two thin lenses (called " elements "), and a plane parallel sheet of glass. The theory of thick lenses, and lens combinations, is discussed in chapter iii.; this theory, as explained by Mr. Taylor, is much simpler than that usually given in books on geometrical optics, although a further simplification is possible and desirable. At this early stage the reader is brought into touch with practice by using the formulæ that have been evolved, to calculate the focal lengths of some well-known lens combinations, including the Cooke process lens. Such calculations occur at short intervals throughout the book, and add much to its value.

Spherical aberration is discussed in chapter iv. The ordinary formula to the second degree of approximation is obtained, and is simplified by the aid of a device due to Coddington; a formula to the third degree of approximation is also worked out, but the reader may omit the investigation leading to this on a first reading, as it is somewhat complicated, though presenting no difficulty other than those generally met with in dealing with unwieldy formulæ. A geometrical device [1] due to Mr. Blakesley, might have been mentioned here with advantage. It can be easily proved that if all rays proceeding from a point on the axis of a lens pass through the lens in such a manner that the deviation of each is a minimum, then the spherical aberration is a minimum also; and Mr.

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[1] "Geometrical Optics." By T. H. Blakesley. (London : Whittaker and Co., 1903.)

[1] "Geometrical Optics." By T. H. Blakesley, pp. 94-111.

Blakesley has given a simple geometrical means of designing a thin lens to comply with these conditions. Of course, spherical aberration is not the only, or even the most important defect of a lens; but the simplicity of the geometrical construction leads one to wish that expert mathematicians would devote some attention to the subject to see whether graphical methods could not be used in other cases.

Central and eccentric oblique refractions are discussed in chapters v. and vi. respectively. Eccentric oblique refraction is answerable for the phenomenon of "coma" or "side flare," which is discussed in great detail in chapters viii. and viiia. It would be impossible, in the short space of an article such as the present, to deal with the author's treatment of this interesting subject in detail; it must suffice to say that it has now for the first time been brought within the reach of any reader possessing ordinary mathematical attainments who will devote the necessary time and attention to the subject. Some of Mr. Taylor's results are similar to those obtained by Von Siedel, but many are novel. The most important advance effected by Mr. Taylor is the investigation of the foci of oblique and eccentric pencils of large aperture.

The distortion of the image formed by a system of lenses is very fully investigated in chapter ix., where it is shown that Coddington's method is defective in not carrying the spherical aberration of the first lens through to all succeeding lenses, a considerable error being thus introduced. The distortion produced by several combinations of lenses is worked out numerically, and it is shown that, in the case of an eye-piece of a telescope or microscope, an image which is really distorted *may* appear to be undistorted, owing to a peculiarity of the eye. Achromatism is dealt with in chapter x. In reading this, and, indeed, most other chapters of the book, one cannot help being struck by the care with which the author has experimentally tested the results obtained, sometimes finding that an extension of the theory is necessary (see, for example, p. 309). A brief sketch of the errors of the third order is given in chapter xi.

On closing Mr. Taylor's book, we are left to reflect on the living interest which he has given to mathematical investigations, essentially of a somewhat clumsy nature. Throughout the book, theory and practice go hand in hand, and we feel that the labour of solving the complicated problems which arise is well worth the while, for something tangible and useful is gained in the end. It would be well if the examining bodies of the various universities were to attach greater importance to geometrical optics, *studied from an essentially practical point of view*. At present the startling discoveries which have been made during recent years in other branches of physics absorb so much attention that many students who sit for advanced examinations in physics are culpably ignorant as to even fundamental properties of lenses. Questions on geometrical optics are rarely set by examiners; and when they are, they are too often merely mathematical exercises. Since accurate experimenting so often involves the use of lenses and other optical appliances, this state of things is greatly to be regretted.

EDWIN EDSER.

A THEORY OF THE ÆTHER.

Æther: A Theory of the Nature of Æther and of its Place in the Universe. By Dr. Hugh Woods. Pp. xii + 100. (London : The *Electrician* Printing and Publishing Co., Ltd., 'n.d.) Price 4s. 6d. net.

THIS book is a more elaborated presentation of the views as to the nature of æther set forth by the author in a pamphlet published in 1898. The æther is "regarded as possessing properties such as might justify its being described as a gaseous fluid, composed of atoms almost indefinitely small as compared with recognised chemical atoms." Again, "Æther is a fluid whose ultimate particles, or atoms, are so small that they pass into the minute crevices of spaces in the most solid bodies." This view has much in common with some of the older theories of the æther, and is almost identical with that proposed by Mendeléeff in his tract, "An Attempt towards a Chemical Conception of the Æther" (1902), and which is referred to by the author in support of his views. No attempt is made to overcome the objection first urged by Maxwell to any theory as to the nature of the æther which postulates a discrete structure for it—that all the energy of the universe would have been transferred to it—and the same objection applies even if the æther is regarded as a limiting case of a medium possessing such a structure.

The theory proposed by the author cannot, therefore, be accepted as an ultimate theory of the æther. There remains the question whether this idea of the æther affords a satisfactory working model which could be used to give a concrete representation of physical and chemical phenomena, and enable their course to be definitely followed. The theory is applied to a wide range of phenomena, including gravitation, chemical changes and reactions, heat, light, electricity and magnetism. Many of the explanations that are claimed as consequences of the particular theory would follow from any theory of the æther that assigns to it the fundamental properties of a moving system. The reasoning is in general vague, and the argument is never pushed far enough to enable a quantitative comparison to be made. A few examples will suffice to show the character of the reasoning. On p. 3 the following argument is given :—

"The solar system appears to move through space, borne along in an enormous volume of swiftly flowing æther. Now the resistance offered to the free flow of the æther by the partially impervious bodies floating in it is evidently greatest in the line of greatest thickness of each body, and less as the thickness becomes diminished. Accordingly a difference of momentum is thereby caused in the mass of æther, dashing against the body, and there results a current in the æther from places of higher momentum to places where the momentum is lower, with the effect that a whirl, such as occurs in the air under similar circumstances, is produced. These whirls, then, by their continual action, make the bodies more or less spherical, and set them rotating, each on its largest axis, while the whirls, spreading out in ever widening circles, influence the movements of other bodies floating in the same medium." "In this way, the movements and mutual influence of the heavenly bodies may be explained, in a perfectly rational manner, and without imagining any occult power of attraction."